Critical Analysis of the Use of Uroflowmetry for Urethral Stricture Disease Surveillance

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OBJECTIVE To critically evaluate the use of uroflowmetry (UF) in a large urethral stricture disease cohort as a means to monitor for stricture recurrence.

MATERIALS AND METHODS This study included men that underwent anterior urethroplasty and completed a study-specific follow-up protocol. Pre- and postoperative UF studies of men found to have cystoscopic recurrence were compared to UF studies from successful repairs. UF components of interest included maximum flow rate (Q_m), average flow rate (Q_a), and voided volume, in addition to the novel post-UF calculated value of Q_m minus Q_a (Q_m-Q_a). Area under the receiver operating characteristic curves (AUC) of individual UF parameters was compared.

RESULTS Q_m-Q_a had the highest AUC (0.8295) followed by Q_m (0.8241). UF performed significantly better in men ≤40 with an AUC of 0.9324 and 0.9224 for Q_m-Q_a and Q_m respectively, as compared to 0.7484 and 0.7661 in men >40. Importantly, of men found to have anatomic recurrences, only 41% had a Q_m of ≤15 mL/s at time of diagnostic cystoscopy, whereas over 83% were found to have a Q_m-Q_a of ≤10 mL/s.

CONCLUSION Q_m rate alone may not be sensitive enough to replace cystoscopy when screening for stricture recurrence in all patients, especially in younger men where baseline flow rates are higher. Q_m-Q_a is a novel calculated UF measure that appears to be more sensitive than Q_m when using UF to screen for recurrence, as it may be a better numerical representation of the shape of the voiding curve. UROLOGY 91: 197–202, 2016. Published by Elsevier Inc.

Uroflowmetry (UF) is a simple, noninvasive method to evaluate voiding function in patients experiencing lower urinary tract symptoms.[1,2] It is often combined with other metrics, including the International Prostate Symptom Score, in the initial diagnosis and follow-up of benign prostatic hyperplasia (BPH), and other causes of obstruction.[3] In patients with urethral stricture disease (USD) who have undergone urethroplasty, UF is one of the most frequently used tests to monitor for stricture recurrence.[4] However, UF's use as a stand-alone tool to screen for recurrence following urethroplasty has never been rigorously validated.

It has been well established that the maximum flow rate (Q_m) in patients with USD is significantly diminished relative to age-matched normal controls.[5,6] This knowledge has been extrapolated to the post-urethroplasty setting, where commonly used cutpoints of a postoperative Q_m of less than 10 mL/s or a postoperative Q_m of less than 15 mL/s are used as indicators of urethral stricture recurrence.[5-7] Similarly, when UF data are available both pre- and postoperatively, a change in Q_m following surgery of less than 10 mL/s has also been suggested as a predictor of recurrence.[8] The goal for each of these UF parameters is to minimize the invasiveness of postoperative screening while maximizing the ability to find recurrences.

The purpose of this study is to rigorously evaluate the capability of individual UF parameters, such as Q_m and average flow rate (Q_a), as well as a novel hybrid measure (Q_m-Q_a) to monitor for urethral stricture recurrence. Use of Q_m-Q_a has not been described in prior literature and attempts to provide a simple method to quantify the shape of the voiding curve. The study tested two hypotheses: (1) when compared to the gold-standard cystoscopy, UF parameters will have high test (screening) sensitivity and specificity, and (2) the sensitivity and specificity of UF to screen for stricture recurrence will be diminished in older patients.

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MATERIALS AND METHODS

Subjects

The Trauma and Urologic Reconstruction Network of Surgeons (TURNS) is a multi-institutional effort that aims to prospectively monitor urethroplasty outcomes. The shared, centrally located web-based TURNS database was retrospectively queried for all men who had undergone anterior urethroplasty between 2009 and 2014. Data for these men were prospectively collected under Institutional Review Board-approved protocols, with patient consent obtained prior to surgery. Study inclusion criteria included men who had a follow-up cystoscopy at 3, 6, or 12 months postoperatively and had a corresponding same-day UF study. In patients with multiple follow-up cystoscopies/UF studies, the most recent instance was used for analysis. Recurrence was defined as the inability to advance a 17 French cystoscope past the previously reconstructed portion of the urethral lumen with minimal force; neither symptoms nor requirement for secondary operations were considered in this definition.

UF

Interpretation of UF readouts was made by the surgeon of record as per study protocol. Basic parameters of UF included Q_m, Q_a, voided volume (VV), postvoid residual (PVR), and shape of the voiding curve. A novel calculated value was Q_m minus Q_a (Q_m-Q_a). The changes (Δ) between pre- and postoperative parameters were also calculated in a subset of men. UF studies with voided volumes of less than 150 mL were discarded from the analysis.

Statistics

Descriptive statistics were first used to characterize the patient demographics, location of urethral stricture, and nature of repair. Men were divided into either a cystoscopic recurrence or successful repair group, and *t* tests were used to assess the differences in pre- and postoperative UF parameters between the two groups. Receiver operating characteristic (ROC) curves were constructed to determine the predictive value of each UF parameter in diagnosing urethral stricture recurrence relative to the cystoscopic gold standard. Sensitivity, specificity, positive predictive value, and negative predictive value of UF parameters to detect cystoscopic recurrence were calculated using predetermined, commonly cited cutpoints. The patients were further stratified into >40 years or ≤40 years of age, and similar analysis was repeated. Follow-up was determined as the time from surgery to the time of the last objective (UF or cystoscopy) data point. Statistical analysis was completed using SAS® 9.3 (Cary, NC), with statistical significance set at $P < .05$.

RESULTS

Demographics

Of the 1181 men in the TURNS database, 323 men met study criteria. The majority of men were excluded because of a lack of postoperative cystoscopy data (n = 524) or an absent or poor UF study (n = 334) from the same clinic visit. Urethroplasty was performed by 7 surgeons from different academic institutions. The mean age of included patients was 44.35 ± 15.26 with a mean follow-up time of 12.84 ± 12.38 months. The most common location of stricture repair was the bulbar urethra (n = 272), followed by the penile urethra (n = 27), and the mean intraoperative stricture length was 3.62 ± 2.93 cm. The most common repair was excision and primary anastomosis (n = 139), followed by substitution ventral onlay (n = 55) and substitution dorsal onlay (n = 42). Using cystoscopic criteria, 58 (18%) of the men in the study were noted to have recurrence.

Preoperative UF Data

Preoperative UF studies were available in 189 (59%) of the men. The mean preoperative Q_m was 9.44 ± 6.82 mL/s, mean preoperative mean Q_a was 5.87 ± 4.40 mL/s, mean VV was 258.12 ± 176.50 mL, and mean PVR was 162.26 ± 198.64 mL. Preoperative UF values were not predictive of operative success nor did they correlate with age, stricture length, or stricture location.

Postoperative UF Data

Comparison of postoperative UF data between men with and without evidence of cystoscopic recurrence is shown in Table 1. The mean postoperative Q_m, Q_a, and Q_m-Q_a were significantly different between cohorts; there was no difference in postoperative VV (398.91 ± 204.33 vs 365.33 ± 205.62 mL, $P = .2584$).

ROC analysis was performed comparing UF to cystoscopy (gold standard) (Fig. 1). Postoperative Q_m-Q_a demonstrated the highest area under the receiver operating characteristic curves (AUC) of 0.8295 (95% confidence interval: 0.7426, 0.9164); postoperative Q_m followed closely behind with an AUC of 0.8241 (0.7452, 0.9031). AUC values were not significantly different between Q_m-Q_a and Q_m. Postoperative PVR demonstrated an AUC of 0.6296.

Table 1. Comparison of UF parameters between successful repair and recurrence groups (ranked by ROC AUC)

	Successful Repair Group		Recurrence Group			
	N	Mean ± SD	N	Mean ± SD	*P* Value	ROC AUC (vs cystoscopy)
Postoperative Q_m-Q_a (mL/s)	253	13.27 ± 8.19	57	7.42 ± 5.40	<.0001	0.8295
Postoperative Q_m (mL/s)	265	28.05 ± 12.52	58	17.11 ± 8.31	<.0001	0.8241
ΔQ_m (mL/s)	157	19.88 ± 14.30	32	8.07 ± 10.57	<.0001	0.7638
$\Delta(Q_m - Q_a)$ (mL/s)	146	10.38 ± 9.14	31	4.23 ± 6.19	<.0001	0.7531
Postoperative Q_a (mL/s)	253	14.84 ± 7.47	57	9.80 ± 4.51	<.0001	0.7289
ΔQ_a (mL/s)	146	9.07 ± 8.49	31	3.74 ± 6.07	<.0001	0.7004
Postoperative PVR (mL)	244	72.64 ± 105.30	54	136.67 ± 174.00	.0116	0.6296
Postoperative VV (mL)	265	398.91 ± 204.33	58	365.33 ± 205.62	.2584	0.5647

AUC, area under the receiver operating characteristic curves; PVR, postvoid residual; Q_a, average flow rate; Q_m, maximum flow rate; ROC, receiver operating characteristic; UF, uroflowmetry; VV, voided volume.